slenderer, and less curved than the English specimen. It has a ventral *siphuncle* like the Belemnite, and is supposed to have been attached to a style more than 6 inches in length, like the appendix to the pen of many Calamaries.

The plate illustrating *Conoteuthis* is wanting in most copies of the 'Paléontologie Française,' but occurs in the 'Mollusques Vivans et Fossiles' of the same author, and one of the figures is copied in my Manual, pl. 2. f. 9.

XXXVIII.—*On the Development of the Freshwater Sponges.* By N. Lieberkühn*.

The structures hitherto recognized as belonging to the freshwater Sponges are the following:—The skeleton, consisting of siliceous needles of various forms; the gelatinous substance; the so-called gemmules, which are furnished with a pore, and are either surrounded by a smooth shell, or by a ring of amphidisks†; moveable bodies occurring at certain periods of the year, and effecting the propagation of the sponges: according to Hogg, these move by an endosmotic process; according to Laurent, by cilia. Grant has described similar bodies in the marine sponges, ciliated in front, but not behind; Quekett was unable to confirm this observation, and gives a totally different account of the propagation. Huxley has described spermatozoa in *Tethya*, and Carter in *Spongilla*.

The following observations have been made almost exclusively upon specimens of *Spongilla fluviatilis*, which I examined almost daily in the fresh state during two summers and a winter. They are very common in the river Spree at Berlin, especially upon old wooden posts, and at the bottom of the water.

Skeleton and Gelatinous Substance.—The siliceous spicula have been frequently described, both in their common and unusual forms (see Dujardin's work upon the Infusoria, and Ehrenberg's 'Mikrogeologie'). Meyen states that their ends are connected together by a delicate colourless siliceous mass. I have found this formation, especially in dead sponges, upon which however gemmules and young sponges are often situated; but the connecting material is not silica, for it is destroyed by a red heat, the needles and amphidisks being left. The needles are usually so arranged that several form a rod, the apex of which is applied to the apex of similar rods at an obtuse angle.

* From Müller's Archiv, 1856, i.

† The term *Amphidiscus* was applied by Ehrenberg to a supposed genus of Infusoria, consisting of bacillar spicules of sponges with discoidal ends. —Ed.

These rows of rods project slightly outwards beyond the surface of the sponge, and are further connected with each other by groups of needles. The distance they are apart from each other is easily recognized in a branched sponge which has been kept out of the water for a short time; the apices of the rods project strikingly, and render the surface of the sponge spinous. Each projecting point is seen under the microscope to consist of a bundle of several needles.

The gelatinous substance has been examined most accurately by Dujardin. Small portions exhibit under the microscope Amœba-like movements; but whether these are vital phænomena, as supposed by Dujardin, or are connected with decay, is unknown. Other portions were furnished upon part of their surface with long cilia, by means of which they rapidly changed their position, at the same time emitting processes from the portion free from cilia, and again retracting them, just like Amœbæ. The ciliated portions were not found in winter, but appeared in the spring; in the winter, only those exhibiting the Amœba-like movements were present. These portions, which are always obtained by spreading living Spongillæ upon an object-glass, are not, however, amorphous masses, as represented by Dujardin, but frequently exhibit distinct structures having the form of a cell: this is especially observed in winter, when the granular matter is not so abundant. When the Amœba-like movements cease in one of these masses, a nucleus and a nucleolus become visible; and at this time, not merely a part of the gelatinous mass consists of them, but the entire sponge.

I have never succeeded in displaying the cell-membrane itself; hence the use of the term 'cell' is not at present justifiable, being used for the sake of brevity. Sometimes the nucleus with its nucleolus is found isolated between other uninjured cells, especially when the sponge is not perfectly fresh. The cells are $\frac{1}{1200}$ inch in diameter, the nucleus $\frac{1}{2300}$, the nucleolus $\frac{1}{9000}$. Frequently the nucleolus only is visible in the cells, and sometimes not even this, the interior of the globule being then filled with green or colourless granules. Frequently also the cells do not attain the above magnitude. In some cases I found structures containing within them foreign bodies, such as Diatomaceæ; in other respects these exactly resembled the sponge-cells, containing also a similar nucleolus; a contractile vesicle was absent; they emitted and retracted processes, and were possibly true Amœbæ, in which often no trace of a contractile vesicle can be detected. True Amœbæ with contractile vesicles are not rare in sponges.

The Spongillæ generally abound with infusorial life, especially in winter. I found, in the course of last winter, large numbers of *Paramecium Aurelia, Paramecium Colpoda, Chilodon cucullulus*; several species of *Trachelius*, especially *Trachelius ovum*; less frequently the various forms of *Amphileptus*, especially *Amphileptus Anser* $\frac{1}{24}$th of an inch in diameter, with a bacillar coat to the œsophagus, resembling *Prorodon*, which was also present; moreover, *Loxodes bursaria*, several species of *Bursaria* and *Ophryoglena*. Of the *Oxytrichina* were found principally *Stylonichia, Urostyla,* and *Euplotes*.

The Gemmules.—The living sponges are often situated not directly upon wood, stones, or other objects, but separated from them by a peculiar dark brown earthy mass, often several inches thick. This consists principally of the remains of the dead sponge, empty shells of gemmules with their amphidisks, various siliceous needles and decayed gelatinous substance; sometimes it contains brown gemmules, the contents of which are susceptible of development. In many the developing power of the contents is extinct, and they consist merely of extremely slender acicular crystals and a detritus-like mass; the crystals are too minute to allow of the determination of their shape, yet the angles are perfectly distinct in some of them. In a few instances the dead and broad sponge retained exactly the form and colour of the living, but the microscope showed that the cells were absent: between these acicular skeletons gemmules were also present. The dead branched sponges, which exist mostly at the bottom of the water, are frequently so densely covered with gemmules as to appear grey or greenish; the points of the needles then project beyond the gemmules; these again are often entirely covered by new sponge-formations, and are not visible until the sponge is broken. In the lowest layers of the living broad sponge, which bound the dead layers, large numbers of shining white gemmules are sometimes found; they resemble in general the ordinary brown gemmules; their shell is very firm, and when pressed offers considerable resistance; but the amphidisks are remarkably distinct. Their contents consist of the well-known globular masses, composed of smaller or larger fat-like granules and albuminous matter,—are of about the size of the largest sponge-cells, and when pressed are easily broken up. Other gemmules found here are distinguished by a very soft transparent shell, which is immediately burst, even when the glass-cover is carefully laid upon the object; their amphidisks are also very distinct, but the globular masses contained within them do not break up very easily. When a piece of one of these sponges containing the above-described formations is dissected under water with fine needles, isolated whitish ill-defined globular pieces, of about the size of the gemmules, are usually detected, with the following properties. Even under a low magnifying power, two different layers of the substance are distinguishable,—the uppermost possessing a low refractive power, about equal to that of the ordinary sponge-cells, the inner globular mass being highly refractive, almost like aggregations of fat. When these are compressed by a glass-cover, they become resolved into two kinds of cell-formations, both of which are of about the size of the sponge-cells. The innermost, which belongs to that portion which refracts the light most strongly, adhere firmly together, and consist of a sarcoid mass, in which tolerably large fat-like granules are densely interspersed. When isolated, they exhibit motions resembling those of the sponge-cells; they emit processes into which the granules enter, and again retract them. When forming a larger aggregation, this resembles a lump of fat which begins to fuse, and emits the liquid in separate striæ in all directions. When suitable pressure is made upon the mass, the original separate pieces are distinguishable, but of the most variable forms. I was unable to find in them the delicate transparent coat which surrounds the white gemmules above described. In its place was found only a layer of firmly cohering cell-like globules, some of which resembled the sponge-cells in the arrangement of the granules and the nucleolus, whilst the others enclosed amphidisks. Some of the enclosed amphidisks had exactly the same form as those usually surrounding the gemmules; each bounding by the periphery of its disk a circular portion of the interior of the shell of the globule, which it encloses. In others the two disks were not present, but a slender rod with slightly capitate ends existed in the interior of the cell-like formation; in others again, a row of extremely slender setæ radiated at right angles from the knob of the rod. If these setæ were broader and the stalk thicker, the form would be that of the ordinary amphidisk. The outlines of the cellular body furnished with an amphidisk are as sharp and distinct as in the sponge-cells, but I could not find a nucleus in them; sometimes they contained some fat-granules. Among the white gemmules were some with amphidisks enclosed in vesicles situated upon their transparent envelope together with free amphidisks. There can be no doubt that the previously described bodies are imperfectly developed gemmules. Sometimes firmly connected whitish aggregations of sponge-cells are found with them, of the same size and of a spheroidal form. They are also obtained on dissecting a suitable portion of sponge; but usually the cells separate in this operation.

I am not acquainted with similar facts in the case of the sponges with smooth gemmules; neither have I hitherto met with the smooth gemmules and those surrounded with amphidisks simultaneously in the same sponge. Both forms occur at all times of the year. The branched sponges living at the bottom of the river Spree have hitherto only contained smooth gemmules. In the broad sponge which grows upon boards and posts, both forms were met with, but not in the same piece. The ordinary contents of the gemmules have already been accurately described by Meyen (Müller's Archiv, 1839, p. 83), where it is shown that the amphidisks are constituents of the gemmules. In several specimens, the globular arrangement was not present; the finer granules exhibiting molecular motion being present in great numbers.

In regard to the destiny of the gemmules, Meyen supposed that a polyp-like animal was developed in them, and escaped from the pore. Grant had previously stated, that in the marine sponges, at certain times of the year, infusorial beings, ciliated at the anterior end of the body, are produced; these subsequently becoming fixed, and forming sponges.

In the freshwater sponges, Grant did not find the gemmules exhibiting motion, nor were cilia present. Dujardin mentions two forms of reproductive bodies in the freshwater sponges,—the gemmules and the ciliated bodies found by Laurent. Johnston states, that at certain times of the year the gemmules separate from the general mass of the sponges; that they are then furnished with locomotive organs, like Infusoria, with which they might easily be confounded. The results of the observations of Hogg and Carter have already been published in the 'Annals.' Carter found no trace of swarm-spores. The course of development described by him by no means, however, excludes the possibility of his having overlooked them. But the observation that insular groups of germs occur, the contents of which are gradually converted into the variously shaped cells, is correct.

During the month of June of the present and last year, I have frequently observed ciliated swarm-spores of the freshwater sponges; and a number of circumstances prove that they are integral components of the sponges.

That the entire gemmule is converted into the swarm-spore, as supposed by some observers, is incompatible with the facts to be presently described. The shell of the gemmule and the cortical substance of the swarm-spores are totally different in their properties. Very frequently empty shells of the gemmules are met with; and nothing is opposed to Meyen's supposition, that their inhabitants escape from the pore.

The Swarm-spores.—I first detected these after leaving recent sponges for some hours in a glass full of river-water. They are visible even to the naked eye, being about $\frac{1}{33}$ inch in length, and about $\frac{1}{50}$ in their broadest diameter. They are oval, and usually somewhat more pointed at one end, like a hen's egg. The smaller forms are not half so large, just as similar variations exist in the size of the gemmules. In most specimens, without the microscope, a transparent hemispherical space may be distinguished in the anterior, and a shining white one at the posterior part of the body; the distinction of anterior and posterior being based upon their position when swimming, which takes place at about the same rate as in *Trachelius ovum*. They swim in all directions: sometimes at the surface of the water, next towards the bottom, gliding along this, and then rising towards the surface again; sometimes in straight lines, at others forming a circle. When two of them meet, they often swim for some minutes around each other, subsequently going apart; frequently they remain motionless for a time, and then start off again. If touched when at rest, they swim away. They remained in this state for one or two days, when they went to the bottom of the vessel, where they adhered and began to decay. In but few instances, notwithstanding numerous experiments, have I succeeded in inducing their development. After the above time, the substance of the bodies becomes expanded into a delicate layer, in which a structureless mass with the fine siliceous needles is soon all that can be distinguished: the experiments succeeded when spring-water was applied. On the 20th day I remarked that the spots formed by the spores had become larger. Examination showed the presence of the constituents of young sponges, viz. moveable cells, smaller and larger needles, and some germ-granules. The movements are effected by cilia regularly spread over the entire body. They are of about the same length as those of the Turbellaria, but more slender. But what distinguishes them at once from the ciliary apparatus of all known Infusoria, and from that of the Turbellaria, so accurately examined by Schultze, is a kind of epithelial layer upon which they are situated. This consists of a single layer of spherical cells, about $\frac{1}{7300}$ inch in diameter. The cells are not so crowded as to flatten each other, but they are mostly in contact. I have not as yet detected a nucleus or nucleolus in them, but they usually contain some highly refractive granules.

On watching a swarm-spore under the microscope, part of the epithelial layer is not unfrequently seen to separate from some part of the body,—eight or ten connected cells often becoming detached and set in motion in the liquid by their cilia. Each cell has a single cilium, and never more than one. In a few not perfectly fresh swarm-spores, the surface was divided into several circular and irregular spaces, which under a low magnifying power appeared like large cells, but under a high power became resolved into groups of the above-described small cells.

On dissecting larger portions of sponges, within which swarm-spores exist, the latter are easily lacerated, and fragments only of them become separated for examination, in which the ciliary motion continues active. Dujardin was not aware of the origin of these portions when he described the movements of the sponges. It sometimes happens also, that the spermatozoa-like bodies, hereafter described, adhere to a smooth piece of sponge, which exhibits the Amœba-like movements, and that they carry it about with them in the liquid. These bodies were also unknown to Dujardin. I am unacquainted with the other moveable forms of the sponges which Dujardin calls Monad-like.

Beneath the epithelial layer the cortical substance is situated, the thickness of which is considerable in comparison with the cellular layer—it is visible even to the naked eye. Even under a high magnifying power, no definite structure could be detected in it. It forms a gelatinous mass, in which here and there some granules of fat are scattered, without regular arrangement. When isolated portions of sponge are separated by dissection, so that they are unconnected with the cilia, they exhibit the same locomotive phænomena as the sponge-cells themselves.

Next to the cortical substance comes the medullary portion, which fills the interior of the spore as a spheroidal mass. Even under a low magnifying power, this is seen to form a body distinct from the cortical layer. The diameter of this spheroid at its broadest part is about $\frac{1}{50}$ inch; but it varies in about the same degree as the swarm-spore itself. Its surface consists of a thinner mucoid layer, and the interior is the same portion of the swarm-spore, which exhibits great varieties in different specimens, whilst the remainder is nearly constant. The larger and most anterior portion of the spheroid in the swarm-spores examined early in June formed a pulpy mass, with fine scattered granules; the posterior part of the spheroid exhibited larger and smaller fat-like granules, forming with sarcoid matter larger and smaller globules, which, when kept for some time in water, became confluent. Many of them contained a very highly refractive body, which sometimes almost entirely filled the gelatinous globule; sometimes these bodies were found without any gelatinous envelope, and were of about half the size of an ordinary sponge-cell. The above-described contents give rise to the white appearance, visible with the naked eye, in the posterior part of the swarm-spore. The entire spheroid, both the transparent and the white portions, contains extremely small siliceous needles, often of exactly the same shape as the adult spicula. The smallest are of a barely measurable breadth, but about $\frac{1}{1800}$ inch in length; the larger being about $\frac{1}{12,000}$ inch broad, and $\frac{1}{750}$ and more long. The larger are either smooth or furnished with minute spine-like processes. The latter form is also not uncommon among the fully developed siliceous needles; and some Spongillæ contain these exclusively. The spicules in the swarm-spores are arranged without definite order. The constant presence of the siliceous needles in the swarm-spores formed the first indication of their origin from the Spongillæ. I found the swarm-spores both in the broad and in the branched sponge, in that with smooth gemmules as also in those with amphidisks.

Differences in the contents of the Swarm-spores.—These consist principally in the greater or less number of the germ-granules. The mature germ-granules are usually spherical, rarely lenticular. Sometimes two of them are relatively so placed, that one extends like a shell over the greater part of the other; such watch-glass-shaped bodies also occur separately, and may also be empty shells. The germ-granules attain the diameter of $\frac{1}{1800}$ inch, but some of them are much smaller. A very highly refractive shell and contents are distinguishable in them. In those occurring in the swarm-spores, the latter are not so distinct as in many of those which are free, and which will be noticed presently. Sometimes they contrast strongly with the shell, and form an ill-defined gelatinous globule; in many germ-granules they cannot be directly perceived. Notwithstanding their simple form, the germ-granules are so characteristic, that they cannot be mistaken for any other objects. At first sight they might be considered as large fat-globules; but the difference is soon made manifest when they are strongly compressed and burst. The number of these germ-granules is so great in many swarm-spores, that, with the minute siliceous needles and the albuminous matter, they almost exclusively make up the medullary mass of the swarm-spores; some being free within it, others aggregated in twos and threes with fatty granules and albuminous matter. These swarm-spores are distinguishable with the naked eye, the highly refractive portion occupying the greater part of their interior, and sometimes forming a perfect spheroid. The above-described form of swarm-spore also appears to contain a white globule, when the anterior part of the spore is directed downwards and the posterior part upwards; but the real state of things is discovered when it swims in the usual manner. It sometimes happened that one of these aggregations of germ-granules with its siliceous needles escaped completely from the swarm-spore when its envelope was burst by pressure; it was of a spherical form, and surrounded by a mucoid, structureless, and readily crushed coat.

The aggregations of germ-granules, of a spherical form, exist free, in vast numbers, in all parts of Spongillæ, but especially at the base. In the same parts I have also found ciliated swarm-spores; they lie completely in the mass of the living sponge, but can seldom be separated from it uninjured. Empty shells of gemmules are not found in these parts. The swarm-spores, however, attach themselves firmly to the empty siliceous skeletons; when detached, they swim about as usual. The aggregated germ-granules seldom contain the small, smooth, and spinous spicula in their interior; but these are often found in their immediate neighbourhood. The mucous envelope is sometimes separable, by evacuating the contents with gentle pressure; but it is structureless. The size of the aggregations of germ-granules varies from $\frac{1}{75}$ to $\frac{1}{50}$ inch. The germ-granules are either uniformly diffused through the entire substance, or are arranged in spherical heaps, and mixed with fatty globules and mucous matter. Many of them exhibit a distinct gelatinous globule, which sometimes contains small fatty granules, at others also a nucleus-like body.

We may here recur to Carter's investigations. As far as I can conclude from his descriptions, the insular groups of germs, which, according to Carter, pass into the variously shaped cells, are my aggregations of germ-granules. But the statement of this observer, that these escape directly from the gemmules, is essentially different from my view. Were we to suppose that Carter had directly observed this occurrence, and that it was not simply based upon supposition, and that the swarm-spores were absent in the sponges examined by him, the difference between the developments of such nearly allied formations would be so great, that it could scarcely occur. In some instances I saw pieces of sponge, the aggregations of germ-granules of which had no longer the definite form, but appeared to be undergoing decomposition. The mucous envelope was also absent, the separate granules being scattered around them.

Moreover, at the period at which all the above-described bodies are present, large masses of sponge are always met with which contain no trace of them. Even in one and the same locality, we find near together Spongillæ containing large numbers of gemmules, swarm-spores, and aggregations of germ-granules, and others in which none of these are present.

Immature forms of the gelatinous substance and of the spicula.—As early as June, white spots about the size of one or several of the aggregations of germ-granules are perceptible on various parts of the sponge, some of which are well defined, whilst others are confluent with the surrounding parts. They are sometimes also found upon other bodies at the bottom of the water, as upon shells of the Mollusca, the exuviæ of the larvæ of the *Phryganidæ*, upon straws, stones, and other similar objects upon which sponges grow. Their microscopic constituents are,—germ-granules of the above-described form and size, which contain either a finely granular globule distinctly contrasted with the enclosing shell, or a cell-like body containing a low refracting body resembling the nucleolus of the sponge-cells; germ-granules, which protrude a sarcoid substance from some part of their surface, and this is continued within the germ-granule, the outline of the portion situated outside being continuous with that lying within; large and small ordinary sponge-cells, some containing a distinct nucleolus, whilst others merely form an aggregation of fine granules and sarcoid substance, exhibiting the Amœba-like movement; variously formed small and large siliceous needles, some resembling the smooth and tuberculated forms met with within the swarm-spores and the aggregations of germ-granules, others being larger, but not so large as the fully developed ones. It is uncertain whether these spicula are developed from the germ-granules; some of them agree in size with these; they are either spherical, drawn out into fine points at the ends, or spindle-shaped, and usually tubercular; they are easily recognized by the refractive power peculiar to siliceous spicula, but in the smallest specimens even this character becomes uncertain. Whether the above-described reproductive bodies of sponges are the only ones which occur, or whether sponge-cells also propagate by spontaneous division, is unknown.

A comparison of Sponges with allied bodies may be met with in J. Müller's memoir upon *Thalassicolla, Collosphæra,* and *Acanthometra**.

The Spermatozoa-like bodies.—In June of the last and the present years, large numbers of moving corpuscles were not unfrequently seen on dissecting sponges, which were readily distinguishable from those giving rise to the movements of the swarm-spores; for in the former the filament is much longer and thicker, and the head much smaller. When swarming, their heads are usually directed towards each other, and their movements greatly resemble those of ordinary spermatozoa. They are seldom met with in the locality where they are developed. They are formed in globules enveloped by a transparent structureless membrane, and surrounded by sponge-cells. The globules are about $\frac{1}{300}$ inch in diameter. They are seen to move to and fro within the globules until these burst, when they swim away in large or small groups, the filament constantly vibrating to and fro. To determine their import as spermatozoa, I endeavoured to observe their entrance into the pore of the gemmule, as perhaps forming the micropyle, but in vain.

* Monatsbericht der Berliner Akademie, April 1855.

As already mentioned, Carter has observed peculiar bodies in sponges, which he regards as spermatozoa. These agree in no respect with the above; they are much larger, and are furnished with a contractile head, whilst the far smaller head of the above-described spermatozoa never exhibits contractions. I have found bodies during the winter in the sponges exactly resembling Carter's figures; these I can only regard as large and small specimens of *Trachelius trichophorus*, the occurrence of which in sponges Carter does not mention; more rarely I found a kind of Monad, probably identical with Dujardin's *Cercomonas acuminata*; this differs, however, importantly from all the components of sponges, in the presence of a contractile vesicle. On the other hand, the spermatozoa which Huxley has figured as those of *Tethya* closely resemble those of the Spongillæ; but Huxley has said nothing about either their origin or their power of motion.

XXXIX.—*On the Development of the* Chitons. By Prof. S. Lovén*.

When on a visit to our Western Skerries three years ago, I had an opportunity of observing the development of *Chiton marginatus*, Pennant (*C. cinereus*, Linn., according to Forbes and Hanley).

Some individuals of this species, which were kept in confinement, laid their eggs, loosely united in clusters of from seven to sixteen, upon small stones. Each egg was furnished with an envelope, which being folded, and as it were vesicular, was of considerable thickness, amounting to about half the total radius. All the stages of segmentation were already passed, and the envelope contained a well-formed moving embryo (fig. 1).

The embryo, 0·18 mill. in length, exactly of an oval form, and without any trace of shell, is divided by a circular indentation into two nearly equal parts; and close to this indentation are attached the cirri, by means of which the movements of the embryo are effected. In the middle of the upper part there is a tuft of very fine filaments, which scarcely exhibit any movements. The lower half exhibits two dark points, one on each side close to the indentation; these are the eyes, of which however only one is usually very distinct. The general form of the animal is somewhat variable, the lower part sometimes giving rise to a tapering process. The young ones, when freed, swim

* Translated from Ofversigt af Kongl. Vetenskaps-Akademiens Förhandlingar, 1855, p. 169.